Space Weather Technical Forecast

Issued on Tuesday, 09 May 2023 at 23:53 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Due to industrial action by Met Office staff on 10 May, which is planned to last for 24 hours, this product has been prepared and issued earlier than usual. The next issue may also be affected by this industrial action.

Space Weather Forecast Headline: G1/G2 Minor/Moderate geomagnetic storm conditions expected late 10 into 11 May. S1/Minor Solar Radiation Storm ongoing. Further R1/R2 Minor/Moderate radio blackouts expected.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High over the past 24 hours, with several M-class flares observed, all from AR3296 (Dac/Beta-Gamma-Delta) in the northwest, peaking at 09/0354 UTC with a M6.5 flare. This sunspot group is a moderately sized, but complex region containing at least one delta spot and shows some evolving intermediate spots. The largest region, AR3297 (Ehc/Beta-Gamma) in northern centre disc appeared largely inactive, although some penumbral development surrounding the large mature positive polarity spot has occurred. These sunspots are among ten on the current disc, with one unnumbered region. All others are small and/or simple regions at present. A number of CMEs were observed leaving the sun in the past 24 hours. Overall, the majority if not all of the ejecta appears to be well-ahead or behind of Earth orbit, however, some Earth-directed component cannot be completely ruled out.

Solar Wind / Geomagnetic Activity: The solar wind, as recorded by DSCOVR at L1, was mainly indicative of a positive polarity fast wind, most likely that from CH01 or perhaps CH99 given the mainly positive phi angle (away from the Sun). Solar winds showed and declining trend and remained at mostly slightly-elevated levels throughout. The solar wind density was mainly at average levels. The IMF remained weak. The north-south component varied weakly, with a peak of +5/- 6nT. Resultant geomagnetic activity was Quiet to Active (Kp1-4).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16, started above the S1 threshold with a peak of 38pfu at 09/0150UTC, then declined below this level at around 09/1300UTC. High energy electron flux (greater than 2MeV), as measured at GOES16, has been at Normal Background levels. The 24-hour integrated fluence has been well below Active levels. At 09/2100UTC 9.16e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High solar activity is likely to continue, with further M-flares likely and a slight chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: A near-full halo CME was observed in coronagraph

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imagery with the M1.6 flare from AR3296 at 07/2323UTC. Although much of the ejecta appears to be directed towards the northwest an Earth-directed component is expected and has been modelled to arrive at Earth either on late 10 or early 11 May. A number of CMEs were observed leaving the sun on 08/09 May. Overall, the majority if not all of the ejecta appears to be well-ahead or behind of Earth orbit, however, some Earth-directed component cannot be completely ruled out from 11 May onwards. Earth is currently in a declining fast wind regime. Slightly elevated winds will probably ease to slow-ambient the first 24 hours of the forecast. A minor resurgence in the solar wind may occur late on 11 May due to yet another positive polarity coronal hole - CH02/+. Any impacts are expected to be weak based on persistence, in any case most likely swamped by the concurrent arrival of the CME (detailed above). On 09 May Quiet to Unsettled activity is expected, giving way to an expected G1-G2 (Minor to Moderate) storm, either late on 10 May or else early 11 May, with a chance of G3 (Strong) geomagnetic storm levels being reached. This risk should recede to a chance of G1 by 12 May given uncertainties in recent CMEs.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is likely to remain below S1 with a declining trend unless any response from the recent M-class flares from AR3296 occurs. High energy (greater than 2MeV) electron flux is expected to persist at normal background to moderate levels, with a possibility of reaching diurnally high levels on 10 May ahead of the anticipated CME arrival either late 10 or early 11 May. The associated 24-hour fluence is forecast to persist below the Active threshold.

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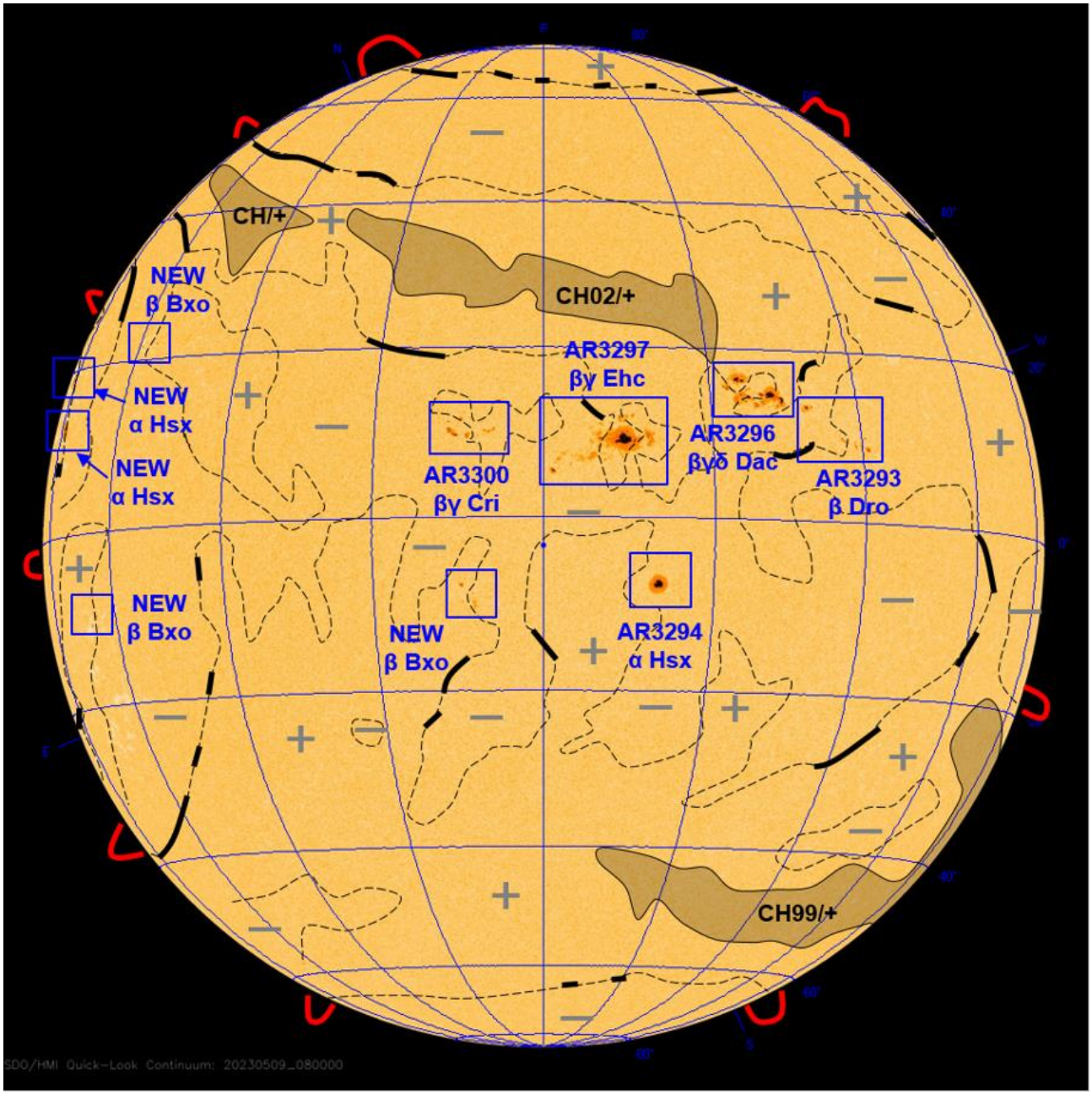
Figure 1. Solar Analysis Valid 0800UTC, 9 May 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A near-full halo CME was observed in coronagraph imagery with the M1.6 flare from AR3296 at 07/2323UTC. Although much of the ejecta appears to be directed towards the northwest, an Earth-directed component is expected and has been modelled to arrive at Earth either late on 10 May or early 11 May. A number of CMEs were observed leaving the sun in the past 24 hours. Analysis of these features is complicated and faint ejecta signatures in some cases. Overall, the majority if not all of the ejecta appears to be well-ahead or behind of Earth orbit, however, some Earth-directed component cannot be completely ruled out from 11 May onwards. The recent M5.0 flare peaking at 09/2052UTC from AR3296 was accompanied by Type II and Type IV emissions and a fast CME seems probable given recent imagery and this may also have an Earth directed component with possible arrival during this guidance period. Earth is currently under the waning influence of a positive polarity fast wind, namely that from CH99/+ and/or CH01/+. Slightly elevated winds will probably ease to slow-ambient levels during 10 May. Some enhancement in the solar wind may then occur late on 11 May due to CH02/+, however any impacts are expected to be weak based on persistence and most likely masked by the expected arrival of the CME that left the sun on 07 May. Solar winds are most likely to increase to elevated or strong levels with the CME, probably decreasing to slightly elevated by the end of 12 May. On 10 May Quiet to Unsettled activity is expected, giving way to an expected G1-G2 (Minor to Moderate) storm, either late on 10 May or else early 11 May, with a chance of G3 (Strong) geomagnetic storm levels being reached. This risk should recede to a chance of G1 by 12 May given uncertainties in recent CMEs but confidence is low for detail by this time.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	80	80	40	20
Strong	G3	No	20	30	10	10
Severe	G4	No	5	5	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
08/0300	Near Full	Flare	AR3296	950 km/s	10/2100UTC +9/-0 hours	N/A

Figure 2: Latest MOSWOC Enlil run and ensemble

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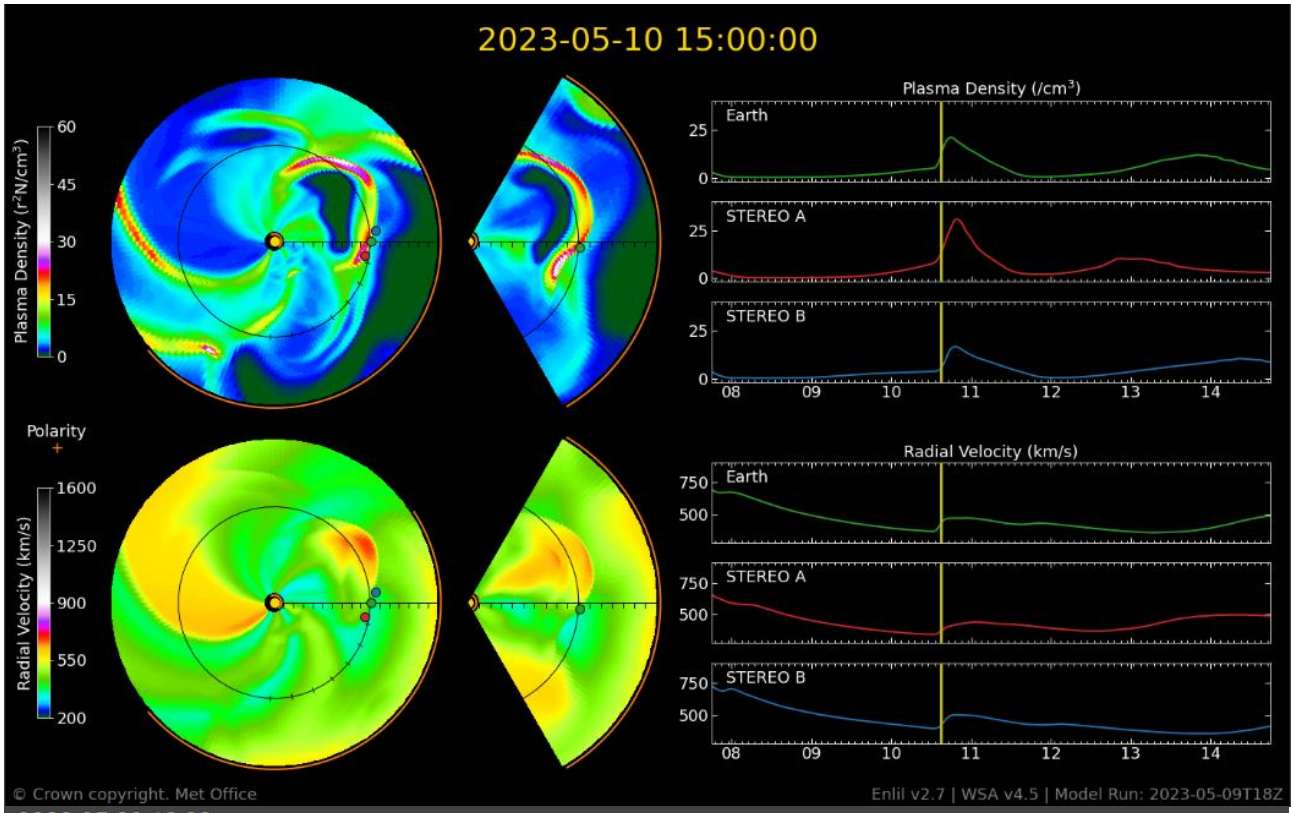
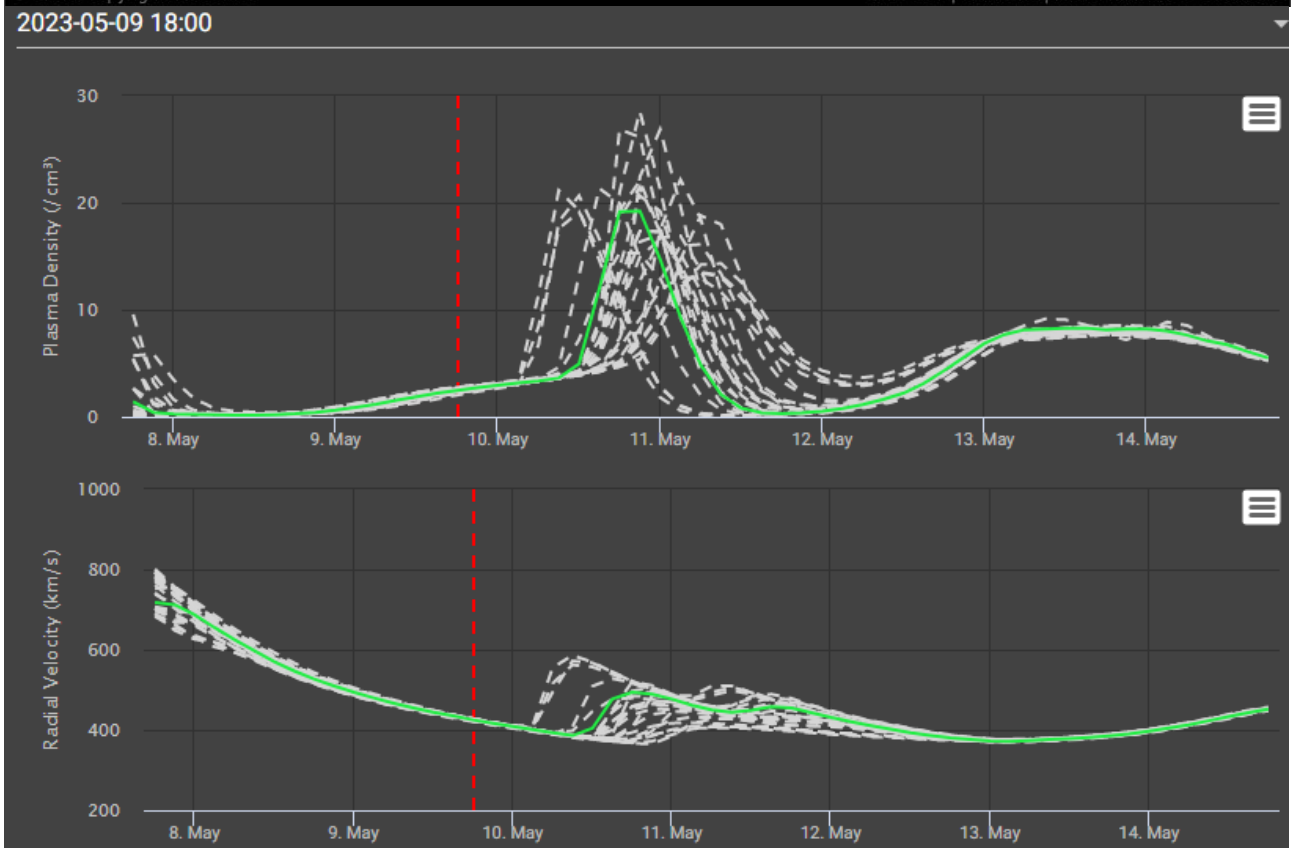
Space Weather Technical Forecast





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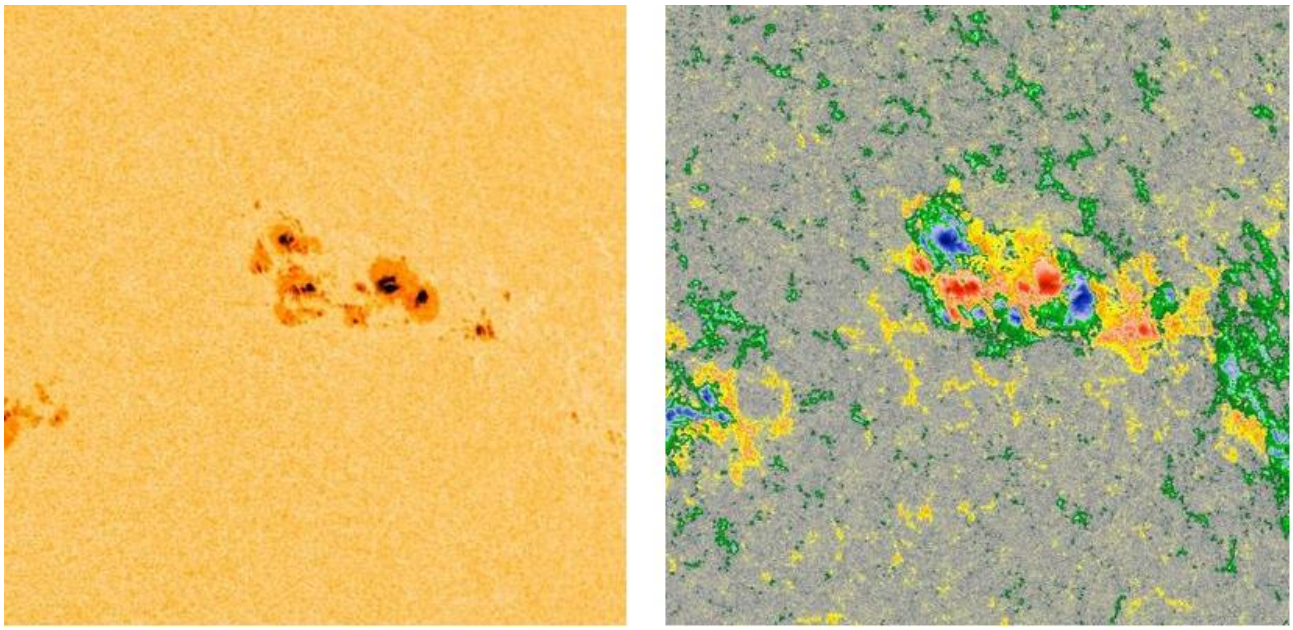
Radio Blackouts - X-Ray Flares:
There are nine numbered and one unnumbered sunspot regions on the visible disc. AR3296 in the northwest remains the most notable sunspot group with significant flare activity, exhibiting a fairly large asymmetric delta spot. The magnetic classification is Dkc/Beta-Delta-Gamma. AR3297 (Ehc/Beta-Gamma) is largely inactive, but with some mixed magnetic field areas sharing faint penumbra. AR3300 has developed in the past 24 hours and is now Dai/Beta with scope for further development. The remaining spots are mainly inactive. Solar activity is High with the largest flare an M6.5 at 09/0354UTC from AR3296. Background flux is at C-class levels. The bulk of the significant flare risk can be attributed to AR3296 and AR3297. Further M-flares are likely with a chance of an isolated X-class flare. There are no significant returning regions due, leading to a flat four-day trend.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	80	80	80	80
Very Active	R3 to R5 X Class	No	20	20	10	10

Figure 3: AR3296 as seen by HMI Intensitygram (left) and HMI colorized Magnetogram (right).



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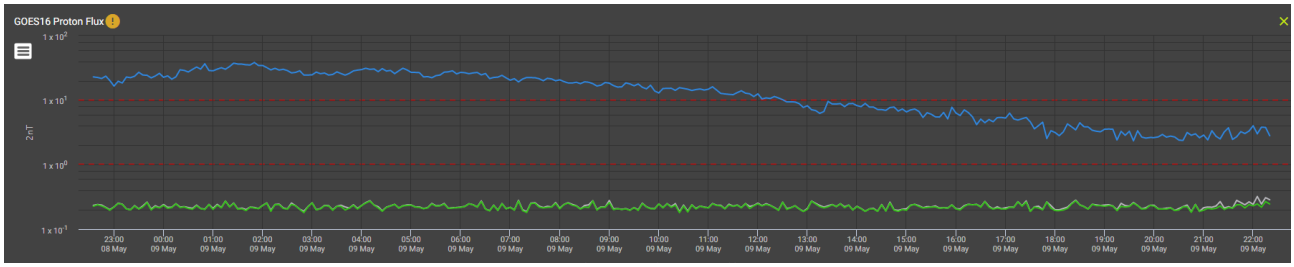
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux, as observed by GOES16 started the period above the S1 threshold in response to the long-duration M1.6 flare from AR3296 at 07/2323UTC and is now below this level at the time of issue. Further flares from the same region may have generated yet more Earth-connecting protons, however, in general a very gradual reduction back to background levels should occur in the coming days. The proton forecast is thus relatively low confidence, as the current gradual decline is reliant on there being no further significant events while the flux is elevated at GEO. Raw disc probabilities suggest a 25% daily chance of this occurrence. Probabilities of S1 levels being breached again should fall through the week, but remain slightly above the 25% raw disc probability on days 1 and 2 given the higher than background starting point and AR3296's apparent propensity for proton-rich events.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	40	30	25	25
Very Active	**≥ S3 ***	No	3	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 24-hour GOES-16 Proton flux trace.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed by GOES16 is expected to persist at normal background to moderate levels, with a possibility of reaching diurnally high levels on 10 May ahead of the anticipated CME arrival either late 10 or early 11 May. This is in accordance with persistence and the latest MOSWOC REFM output, both of which would suggest a continuation near current comfortably sub-active fluence levels.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	20	10	5	5
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output.

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